

The Fate and Effects of Mercury in the Gulf of Mexico and It's Relationship to Offshore Oil & Gas

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What Have We Done? What Do We Know?

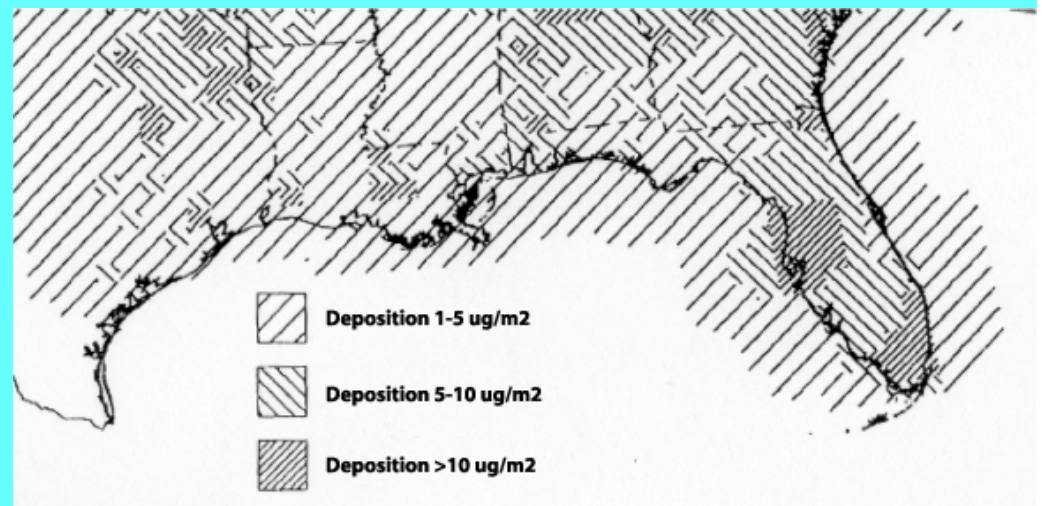
- **Relevant fate & effects studies conducted for over 20 years**
- **Hg studied in discharges, sediments, and animals**
- **Hg is trace component in some discharges**
- **Sediment Hg levels near platforms not significantly elevated**
- **Hg levels in platform organisms not elevated**
- **Offshore platforms not significant source of Hg to marine food webs**

Scope of the Presentation

- Inputs to the Gulf of Mexico
- Hg releases from offshore O&G
- Hg in sediments near platforms
- Hg relative to biological effects
- Availability of mercury
- Uptake in platform biota

Most of the mercury in the Gulf of Mexico enters it from the atmosphere

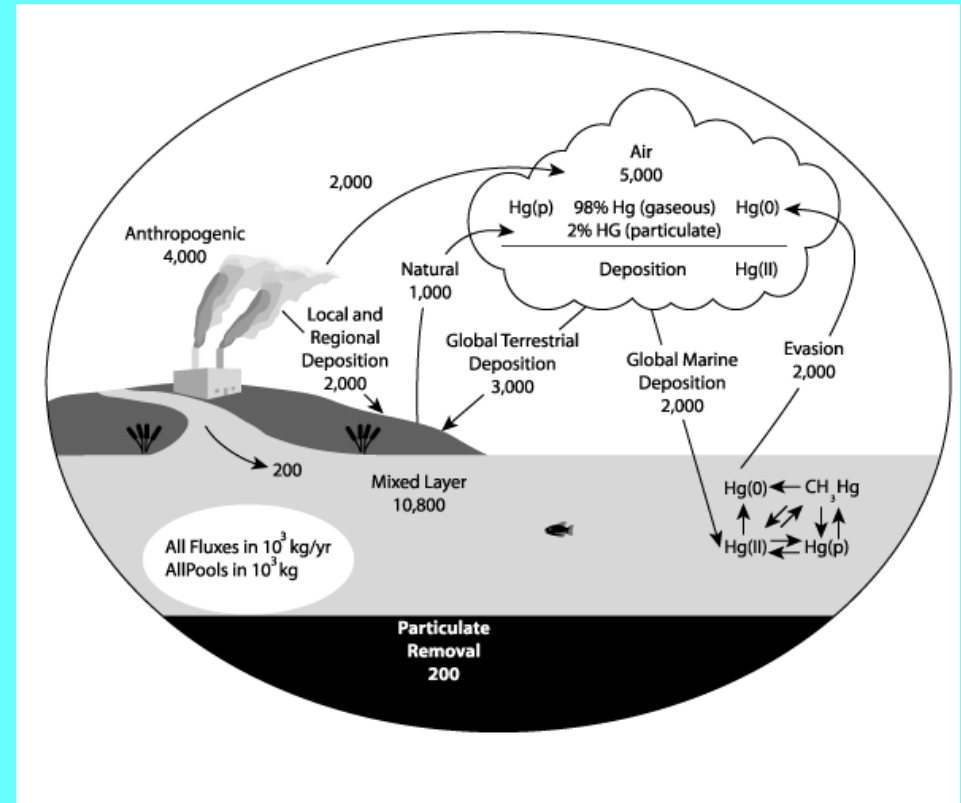
- Approximately 158 metric tons of mercury is emitted to the atmosphere each year from human activities in the US. Most emissions come from coal and waste combustion.
- An estimated 33 tons/year of Hg is deposited from the atmosphere to the surface of the entire Gulf of Mexico in wet and dry deposition. Highest rates are to west and south Florida.



Average aerial deposition rate of mercury in Florida is about 20 $\mu\text{g}/\text{m}^2/\text{year}$

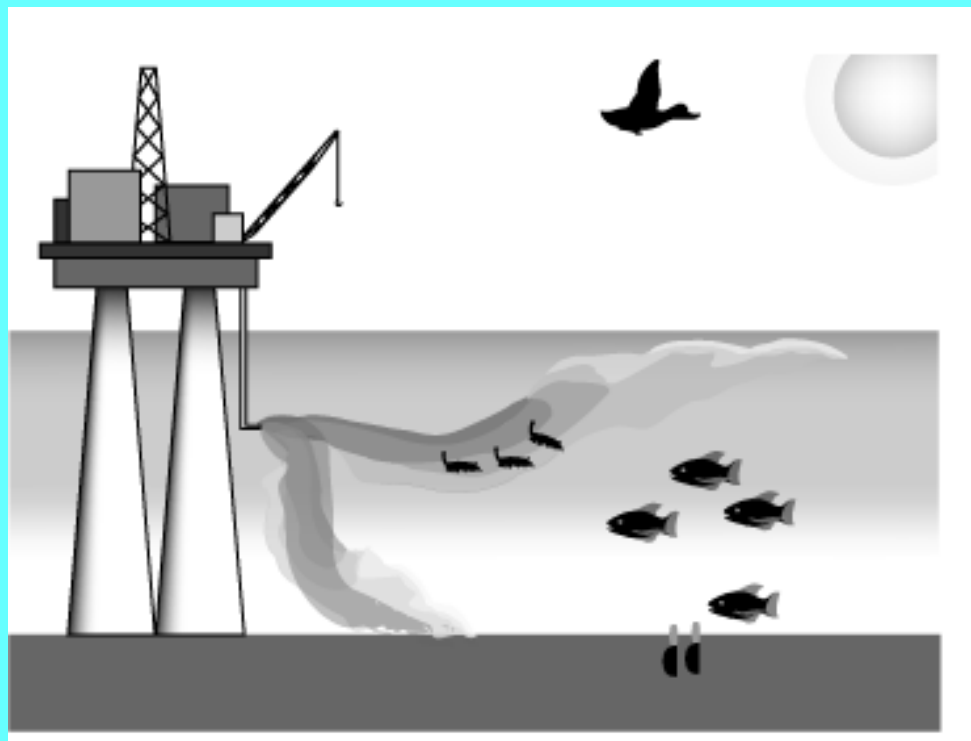
The most important other source of Hg to the Gulf of Mexico is runoff and riverflow from land

- About 85% of the freshwater inflow to the Gulf is from the Mississippi River
- The Mississippi River delivers an estimated 21 tons/year of Hg to the Gulf associated with suspended particles, and 1.2 tons/year in solution.



Less Than 400 Pounds of Mercury Enters the Gulf Each Year in Waste Discharges From Platforms

- About ~ 338 lbs of Hg was associated with drilling muds and cuttings discharges during drilling of 900 wells in 2001. Assumes a mean [Hg] in mud of 0.1 ppm and in cuttings of 0.08 ppm.
- Most of the Hg in drilling muds is present in barite (BaSO_4) as insoluble sulfides.
- An additional estimated 8 lbs was discharged in treated produced water
- The Hg in produced water is metallic (Hg^0) or inorganic (Hg^{+2}).
- Hg discharged in drilling/production wastes is 0.7% of the Hg discharge from the Mississippi River.



Mercury Concentration in Drilling Muds Is Low

Concentrations of Ba often are very high compared to clean sediments, but Hg concentrations usually are not greatly elevated in modern drilling muds.

Mud Discharge Location	Barium (mg/kg dry wt)	Mercury (mg/kg dry wt)
Off Alabama	1500 – 310,000	0.016 – 0.325
Alaska	720 – 7640	0.015 – 0.22
S. California	12,500 – 178,900	0.06 – 0.18
Background Marine Sediments	<50 – 1000	0.01 – 0.15

Mercury Concentrations in Produced Water Usually Are Low

Gulf of Mexico produced water may be enriched in Hg by 100-fold: a 100-fold dilution usually occurs within about 50 m of an offshore produced water discharge.

Metal	Seawater (µg/L)	GOM Produced Water (µg/L)	North Sea Produced Water (µg/L)
Barium	3 – 34	81,000 – 342,000	107,000 – 228,000
Mercury	0.00007 – 0.006	<0.01 – 0.2	0.02 – 2.74

The average concentration of Hg in GOM produced water is about 0.1 ppb.

Approximately 215×10^6 barrels of treated produced water is discharged to surface waters of the GOM each year under NPDES permits.

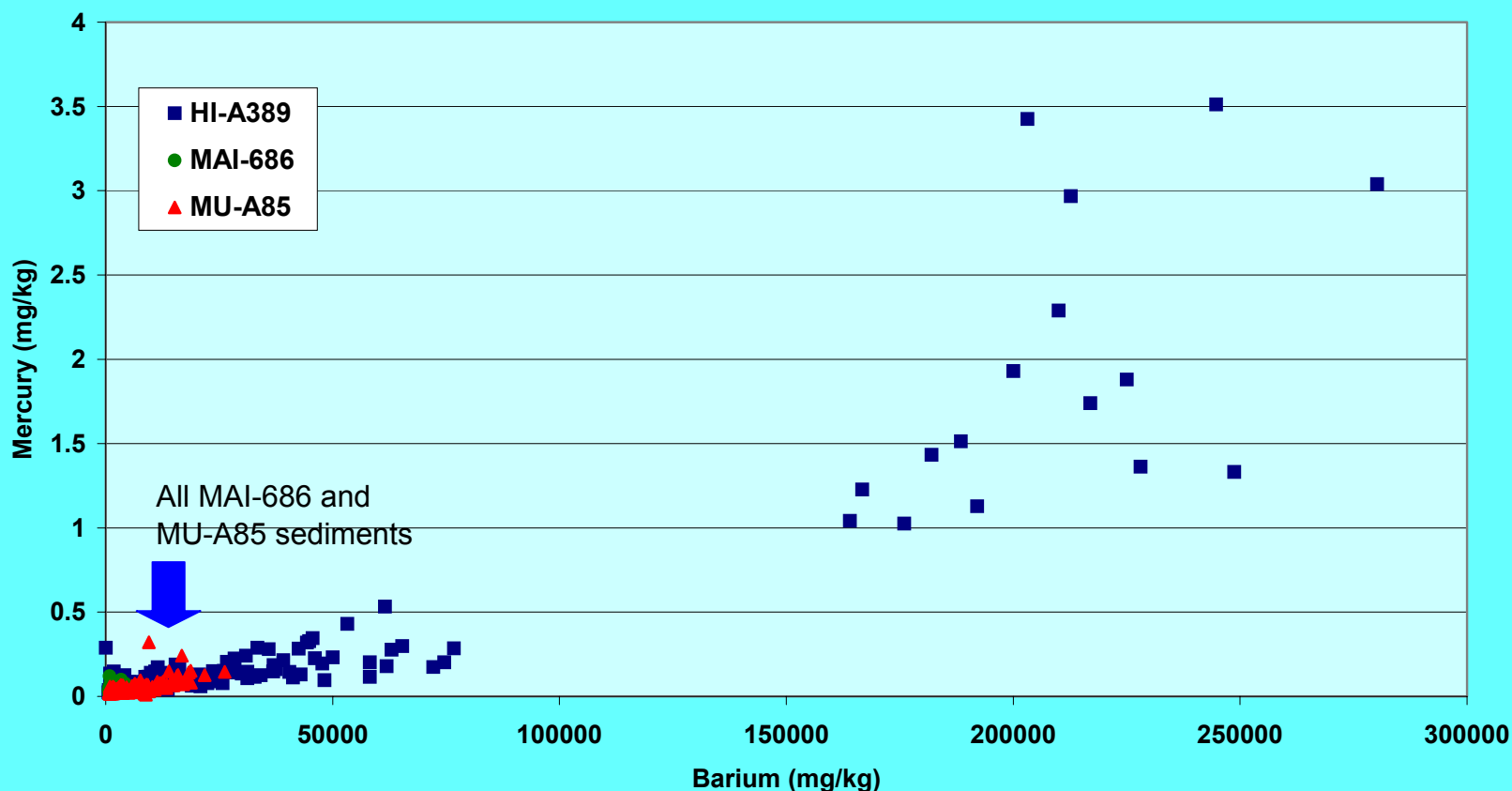
Barium and Mercury Concentrations Sometimes Are Elevated (Compared Background) in Sediments Near Offshore Platforms

Sediments near only 1 platform exceeded 1ppm Hg. Most Hg concentrations were less than about 0.5 ppm. At most sites, Ba and Hg concentrations covaried. The typical background concentration for Hg in sediments is 0.01 – 0.15 ppm.

Platform	Water Depth (m)	Barium (mg/kg)	Mercury (mg/kg)
3 GOOMEX	29 – 157	653 – 280,000	ND – 3.5
Alabama 132	10	ND – 6850	ND – 0.22
GOM SBF Study Drilling Sites	60 – 558	497 – 358,000	0.029 – 0.41
MMS Deep Water SBF Sites	~1100	517 – 344,000	0.038 – 0.72
TX/LA OCS	13 – 102	350 – 56,000	0.006 – 0.50
CA OCS	150 – 200	752 – 965	0.04 – 0.10

16 (of 600) sediment samples from the 3 GOOMEX platforms contained more than 1.0 ppm Hg. High Hg was associated with very high sediment barium concentrations.

Relationship between Ba and Hg concentrations in sediments near 3 GOOMEX platforms



Summary of Platform Sediment Contamination Data

- Data from over 30 platforms
- Only 1 platform above 1 ppm. Max of 3.5 ppm
- Others range from background of 0.1 ppm to maximum of 0.7 ppm
 - Most sediments near platforms in range of 0.2 – 0.3 ppm within 100 m, rapidly dropping off to background levels

Recent suggestions that offshore platforms are focal points of high mercury contamination are false!!

Predicting Biological Effects in Sediments

Long et al. (1995)

Mercury
($\mu\text{g/g}$)

Natural sediment

0.01 – 0.10

Effects Range Median (**ERM**)

0.71

Adverse effects

frequent @ $>\text{ERM}$

Adverse effects **occasional** between **ERM** and **ERL**.

Effects Range Low (**ERL**)

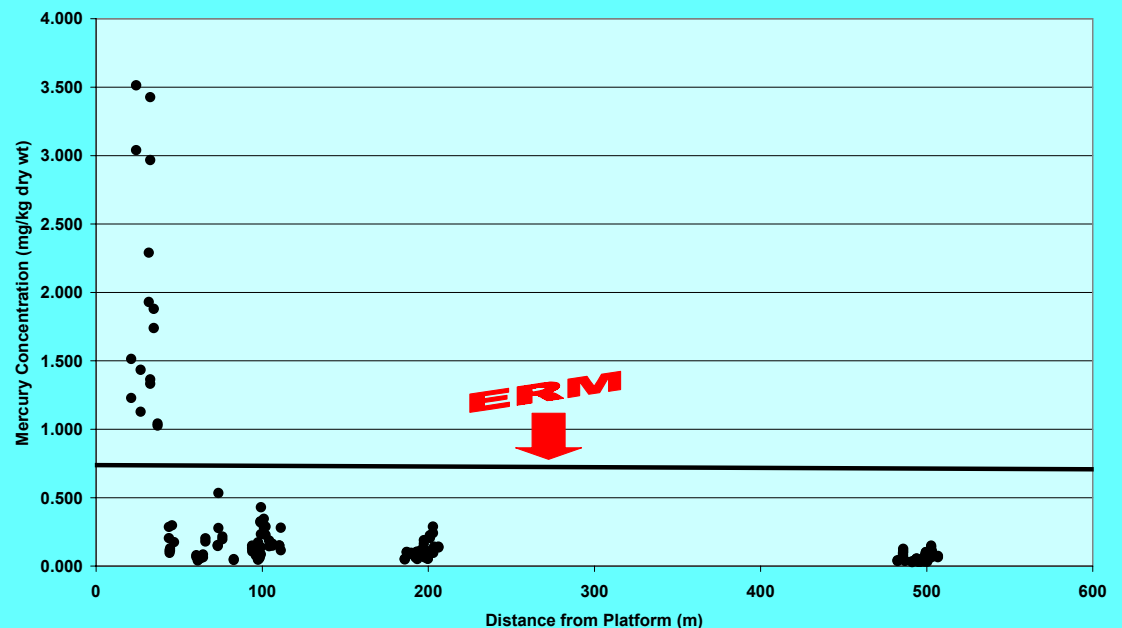
0.15

Adverse effects

rare @ $<\text{ERL}$

By These Criteria, Sediments Near Only 1 Platform Might Be Toxic to benthic Animals, If the Hg Is in bioavailable Forms.

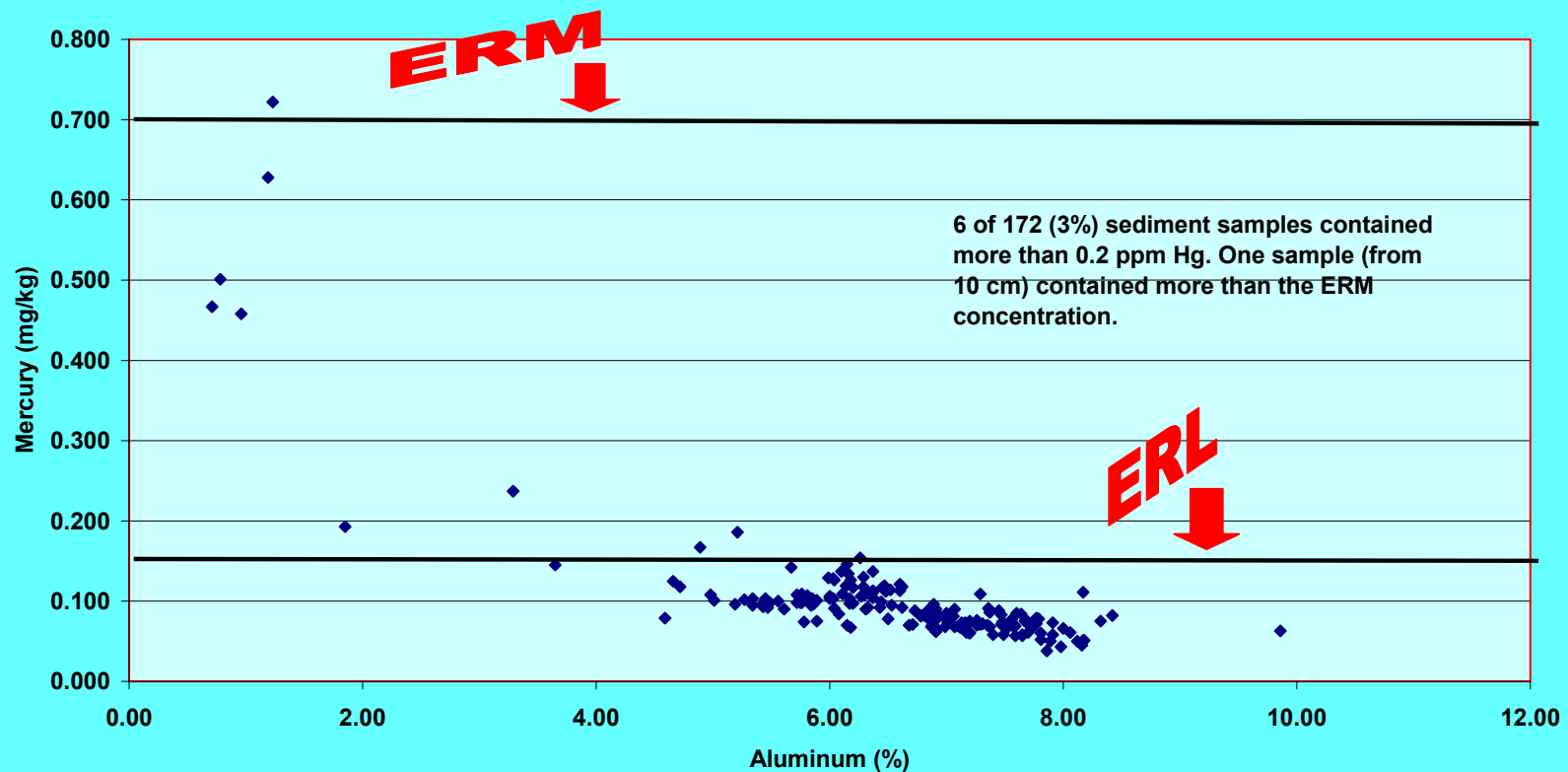
- 16 sediment samples collected within 50 m of HI-A389 where muds and cuttings were shunted to the bottom contained more than 0.7 ppm total Hg.
- There is a good correlation between Ba and Hg concentrations, indicating that the Hg probably was still associated with the barite in an insoluble, immobile, and nontoxic form.



Sediments from 5000 m had same concentration of Hg as those from 500 m, background.

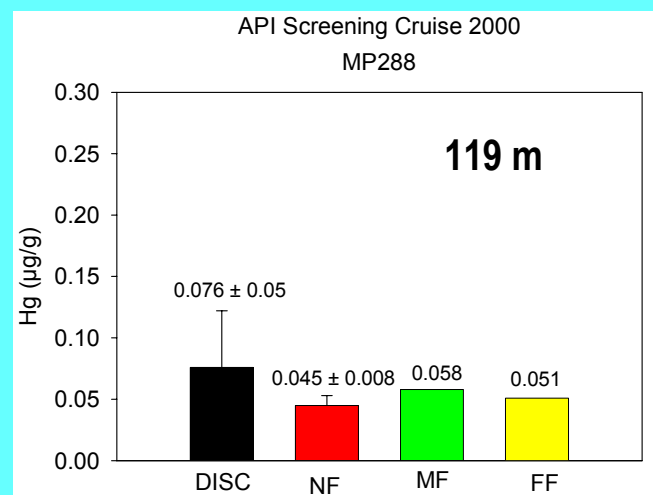
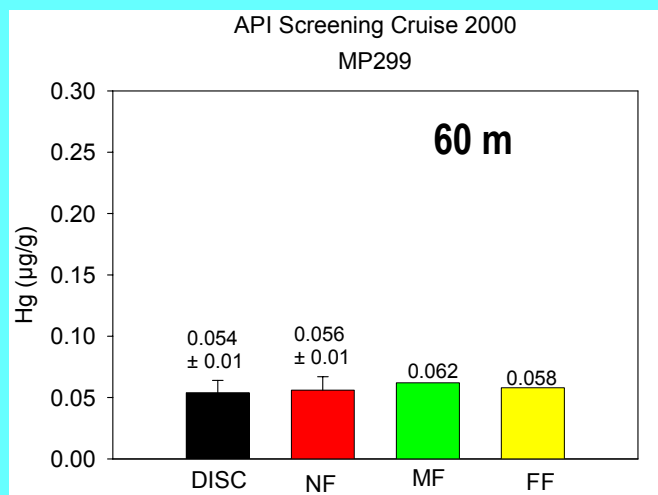
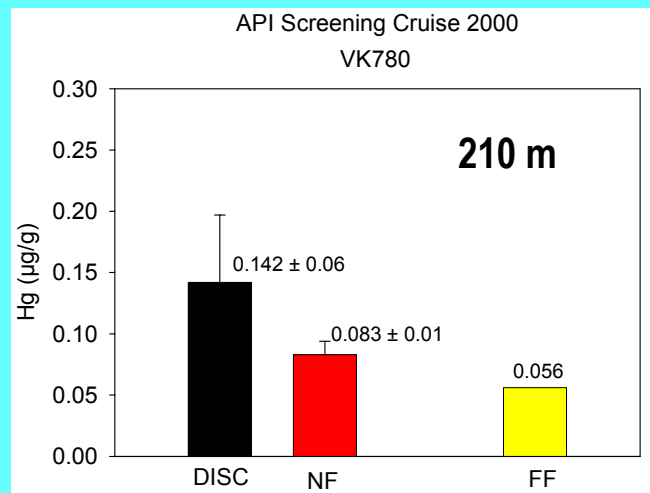
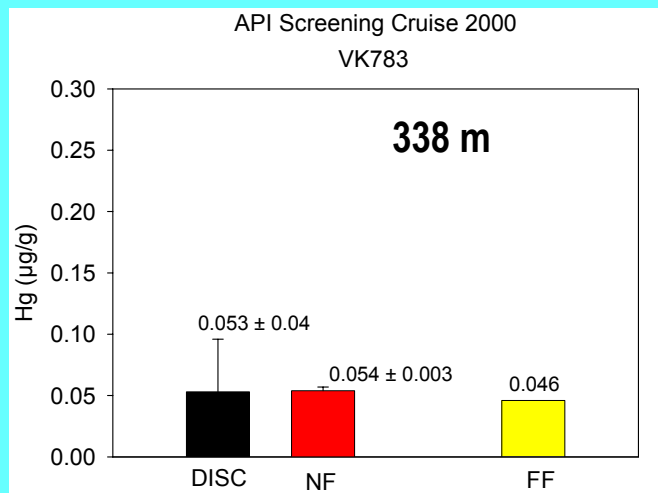
Most Hg Concentrations in Sediments Near MMS Deep-Water Study Platforms Were Below the ERL

Relationship between Al and Hg concentrations in sediments near platforms sampled in the MMS Deep Water Program

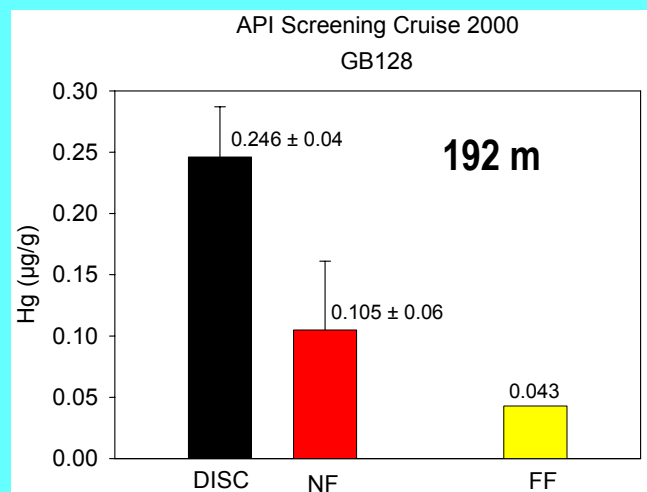
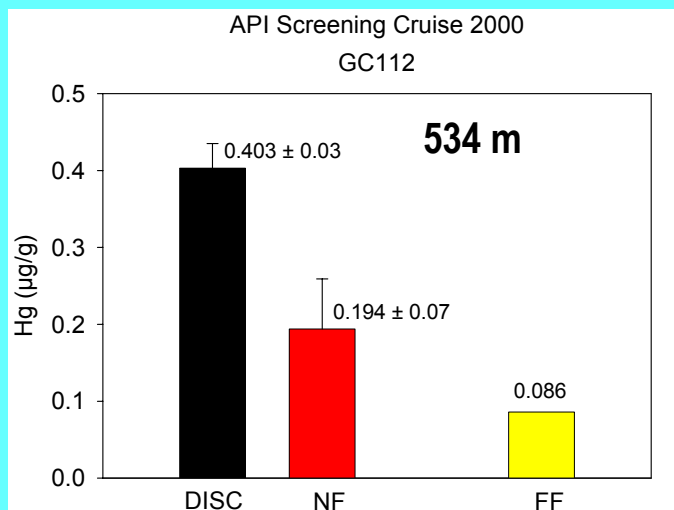
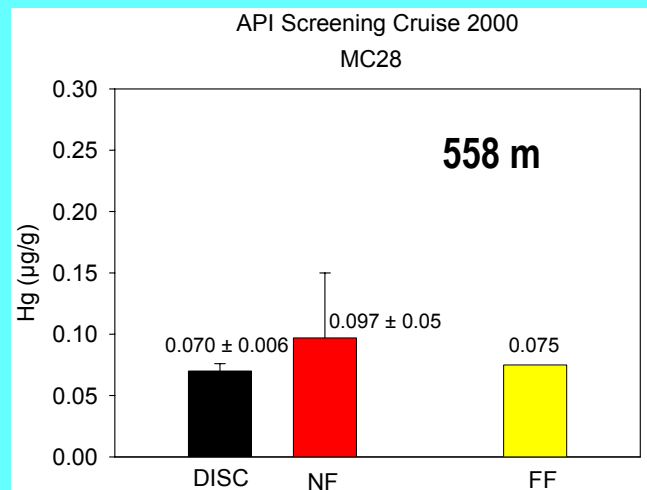
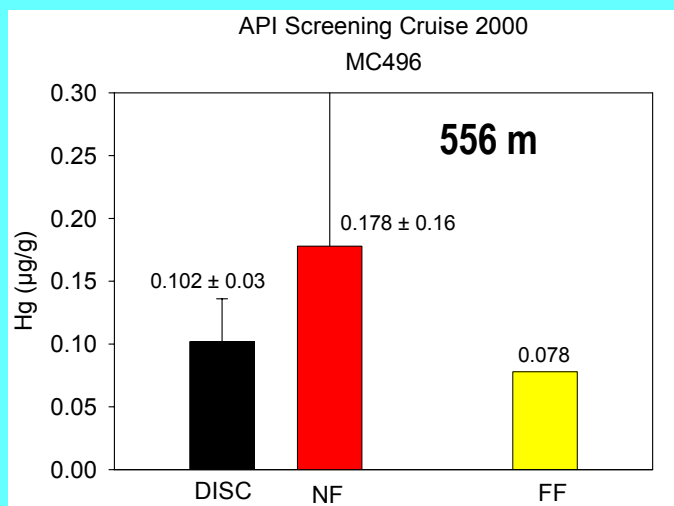


Because Hg in sediments near platforms has low solubility/bioavailability, sediments Between ERL and ERM are unlikely to be toxic.

Average Hg Concentrations Were Below the ERL (0.15 ppm) in Most Sediments Near Platforms Sampled in the Gulf of Mexico SBF Monitoring Program



Some Sediments (Mostly Below Surface in Sediment Cores: DISC) From the SBF Program Contained Slightly Elevated Hg Concentrations. No Mean Concentrations Were Above ERM.



Do Marine Animals From the Vicinity of Offshore Oil and Gas Operations Contain Higher Concentrations of Hg Than the Same Species From Elsewhere? **NO !!**

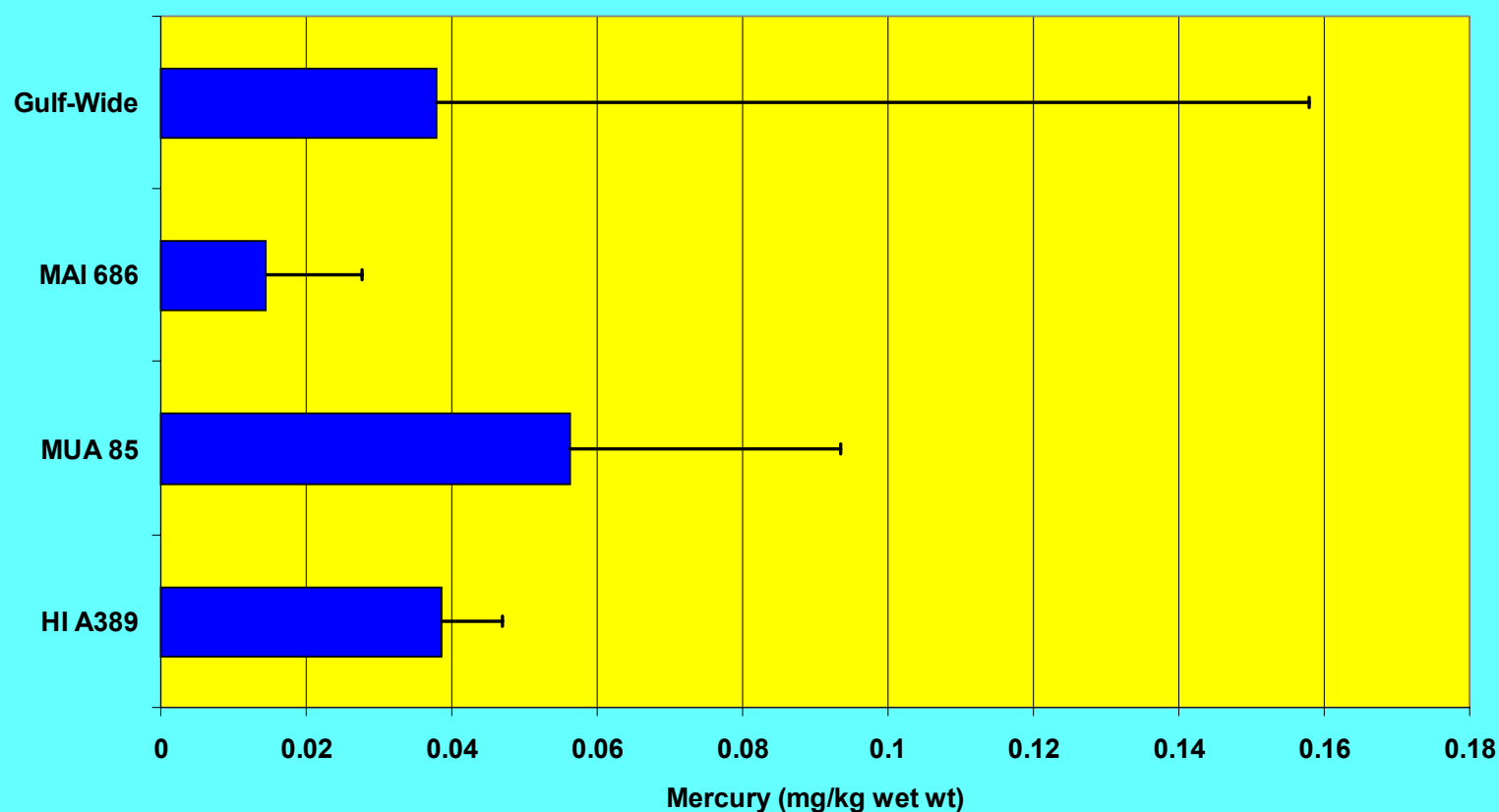
Concentrations of total mercury in bivalve mollusks (mostly mussels and oysters) from National Status and Trends Mussel Watch Sites in coastal waters of the United States (1986-1993). Concentrations are $\mu\text{g/g}$ wet wt and were converted from dry wt by multiplying by 0.2. From EPA (1997).

Region	States	Range	Median
Gulf of Mexico			
Eastern Gulf of Mexico	FL, AL, MS	0.001 – 0.14	0.03
Western Gulf of Mexico	LA, TX	0.0004 – 0.36	0.02
Atlantic			
North Atlantic	ME, MA, RI, CT, NY, NJ	0.001 – 0.14	0.03
Middle Atlantic	DE, MD, VA	0.0006 – 0.07	0.01
South Atlantic	NC, SC, GA, FL	0.002 – 0.20	0.02
Pacific	CA, OR, WA, HI, AK	0.0004 – 0.20	0.02

Oysters from the western Gulf (site of intense O&G operations for decades) usually contain lower concentrations of Hg than those from the eastern Gulf and elsewhere in the US.

Concentrations of Mercury in Penaeid (Edible) Shrimp From the Vicinity of the 3 GOOMEX Platforms Are Similar to Those in Penaeids Throughout the Gulf of Mexico

Concentrations (+SD) of mercury in penaeid shrimp from three platforms monitored in the GOOMEX program, compared to concentrations in shrimp collected throughout the Gulf of Mexico



Mercury Concentrations in Bivalve Mollusks and Crabs Are Similar Near and Away From Platforms in the Gulf of Mexico. There Is No Evidence of Bioaccumulation From Platform Discharges.

Range of mean concentrations of total mercury in soft tissues of bivalve mollusks and blue crabs collected in the vicinity of oil and gas platforms in the Gulf of Mexico. Concentrations are $\mu\text{g/g}$ wet wt. Data from Offshore Operators Committee (1997a,b) and Dept. of Energy (1997a).

Species	Discharging Platforms	Reference Platforms
Jewel Box <i>Chama macerophylla</i>	0.009 – 0.024	0.01 – 0.19
Thorny Oyster <i>Spondylus americanus</i>	0.02 – 0.07	0.02 – 0.05
Eastern Oyster <i>Crassostrea virginica</i>	0.005 – 0.012	0.007 – 0.01
Blue Crab <i>Callinectes sapidus</i>	0.04 – 0.06	0.05 – 0.08

Mean and range of concentrations of mercury in whole soft tissues of marine and estuarine invertebrates from the Gulf of Mexico. Concentrations are $\mu\text{g/g}$ wet wt. From Ache et al. (2000).

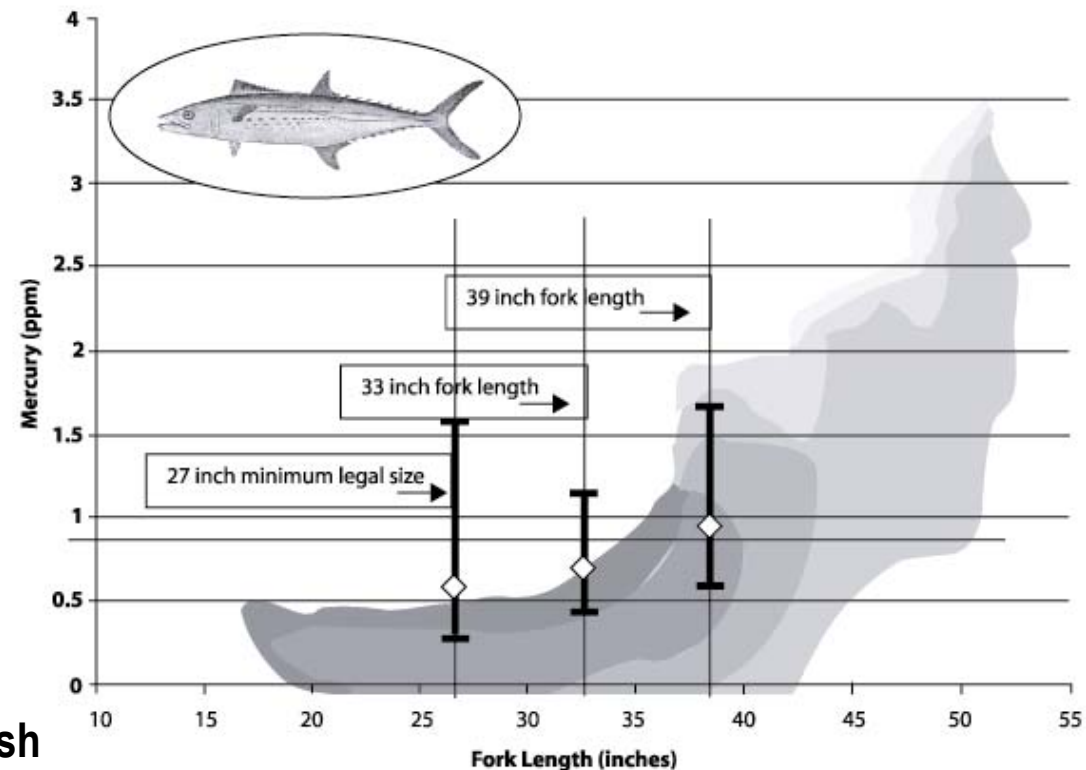
Common Name	Species	No.	Mean (SD)	Range
Oyster	<i>Crassostrea virginica</i>	929	0.07 \pm 0.08	0.01 - 0.58
Jewel Box	<i>Chama sinuosa</i>	5	0.03 \pm 0.01	0.02 - 0.04
Unid. Bivalve	---	3	0.12 \pm 0.02	0.09 - 0.13
Blue Crab	<i>Callinectes sapidus</i>	107	0.24 \pm 0.32	0.002 - 2.65
Stone Crab	<i>Minippe mercenaria</i>	3	1.36 \pm 1.09	0.10 - 2.02
White Shrimp	<i>Penaeus setiferus</i>	5	0.04 \pm 0.03	0.004 - 0.09
Unid. Shrimp	---	2	0.35 \pm 0.17	0.23 - 0.47

Concentrations of Mercury in Muscle of Large Pelagic Fish Increase With Size of the Fish. Largest May Contain Hg in Excess of the FDA Guidelines (1 ppm Wet Wt).

Hg in king mackerel muscle similar along the south Atlantic and in the Gulf of Mexico.

King mackerel caught near platforms in the GOM contain the same or lower concentrations of Hg as individuals of the same size caught away from platforms.

No indication that large pelagic fish bioaccumulate Hg from platform discharges



S. Atlantic data from Moore (2000); GOM data from Ache et al. (2000).

Fish Collected Near Offshore Platforms Contain Muscle Mercury Concentrations Similar to Those in Muscle of Most Fish From Elsewhere and Below FDA and EPA Human Health Guidelines.

Concentrations of total mercury in muscle or whole soft tissues of fish from the vicinity of offshore platforms in the Gulf of Mexico.

Concentrations are µg/g wet wt (parts per million). From DOE, 1997; OOC, 1997).

Common Name	Scientific Name	Mean	Range
Creole Fish	<i>Paranthias furcifer</i>	0.032	0.013 - 0.076
Gray Triggerfish	<i>Balistes carpiscus</i>	0.092	0.005 - 0.46
Hardhead Catfish	<i>Arius felis</i>	0.13	0.032 - 0.36
Red Snapper	<i>Lutjanus campechanus</i>	0.094	0.020 - 0.40
Rockhind	<i>Epinephelus adscensionis</i>	0.099	0.056 - 0.15
Sergeant Major	<i>Abudefduf saxatilis</i>	0.047	0.036 - 0.056
Sheepshead	<i>Argosargus probatocephalus</i>	0.074	0.028 - 0.20
Yellow Chub	<i>Kyphosus incisor</i>	0.020	0.005 - 0.28

FDA guideline 1 ppm wet wt. EPA guideline 0.5 ppm wet wt. Risk-Base Concentration (RBC) for fish collected from platforms is 0.8 ppm.

CONCLUSIONS: Environmental Exposure

- Permitted drilling and production wastes containing about 348 lbs. of mercury are discharged to the Gulf of Mexico each year. This represents 0.7 % of the mercury discharged in water from the Mississippi River, and about 0.3% of the total mercury entering the Gulf of Mexico.
- The mercury in drilling wastes is tightly bound to barite and has a very low solubility and bioavailability.
- Platforms are not sites high mercury contamination. Only 1 platform out of over 30 studied had any samples above 1 ppm.

CONCLUSIONS: Potential Biological Effects

- **Mercury concentrations in sediments near platforms are nearly always well below the Effects Range Median (ERM) concentration, and so pose no risk to bottom-living animals.**
- **Mercury concentrations in edible tissues of finfish and shellfish from the vicinity of platforms are similar to those in the same species collected elsewhere in the Gulf of Mexico: most concentrations in edible tissues are below FDA and EPA action levels.**
- **The data suggests that there is no link between mercury in marine finfish and shellfish in the Gulf of Mexico and offshore platforms.**